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A STUDY OF THE MACKERELS, CYBIIDS, AND TUNAS

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 24

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

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Washington, D. C.
May 1950

United States Department of the Interior
Oscar L. Chapman, Secretary
Fish and Wildlife Service
Albert M. Day, Director

Special Scientific Report - Fisheries
No. 24

A STUDY OF THE MACKERELS, CYBIIDS, AND TUNAS

By

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Translated from the Japanese language by

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Pacific Oceanic Fishery Investigations

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1/ From Suisan Gakkai Hō, Vol. 1, No. 1, pp. 1-24, May 1915.

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In the present taxonomy the tunas and bonitos are included with the mackerels and cybiids in the family Scombridae. This is a little astonishing in view of the tendency toward more and more detailed classification, however, there are many inconveniences in the study of these fishes and for this reason detailed investigations have been naturally delayed.

The fishes at present assigned to the Scombridae are for the most part widely distributed and exist in great numbers. They grow fast, are generally large in size, and their flesh is well-flavored. Consequently they are important economically. The species are particularly numerous in Japan, and about 25,000,000 kan [1 kan = 8.27 lbs.] with a value of 13,000,000 yen are taken each year, showing that these are fishes which are worthy of a great deal of attention.

This study was started in 1912 and was carried on at the University and the Fisheries Bureau. For aid in obtaining materials and reports thanks are due to the various prefectural fisheries research stations and to many of my friends, especially Nagatsugu Akiyama, Seizō Adachi, Torakichi Imano, Shōshi Okada, Naotarō Oda, Kōji Ōta, Eizō Kōno, Koichi Kamei, Rainosuke Kubo, Tokujirō Koshida, Hikozō Shimura, Hidezane Seno, Nisuke Takahashi, Yōzō Nakajima, the late Kōtarō Maeda, Kichitarō Yamada, and Yōjirō Wakiya.

I also wish to express my thanks for the kindness of Dr. Rathburn, assistant curator of the American Museum of Natural History, who sent me specimens of Atlantic mackerels and bonitos, Dr. Jordan, who sent me mimeographed copies of papers, and Mr. Goby, the assistant chief of the Netherlands East Indies Bureau of Agriculture, who sent me specimens of mackerels and cybiids from the South Seas.

As a result of my studies I have found that there are two species of mackerel, five species of cybiids, two species of Oriental bonito, five species of tuna, and four species of bonito, a total of ten genera and 18 species, which occur in Japanese waters, and that these may be suitably divided into three families, the Scombridae, Cybiidae, and Thunnidae. I have also found errors and omissions in past definitions of the relationships between these genera and species. The detailed results of my study will be published in the Journal of the College of Agriculture.

The oldest mention of these fishes in our national literature is in Ekken Kaibara's Yamato Honzō (5th year of Hōei, that is, 1708). He listed the saba, sawara, okisawara, mikouo, shibi, and katsuo. In Shōtoku 2 (1712) Ryōan Terajima in his Wakan Sansai Zue mentioned the katsuo (sujikatsuo, yokowa, mochikatsuo), shibi (uzuwa, mejika, mekuro, makuro, hatsu), and so forth. In Bunsei 10 (1827) Jūbei Kuroda in his Suizokushi recorded the saba (kisaba, hirasaba), sawara (yanagi sawara, okisawara, shirouo, uke), shibi (kuroshibi, maguro, mejika, medaishibi, binnaga, kihata, mebachi), katsuo (mochigatsuo, sujigatsuo, sumadara, uzuwa, shibuwa, yokowa), and so forth.

In 1829 Cuvier in his Regne Animal established under "Les Scombres" the genera Scomber, Thynnus, Orcynus, Auxis, Sarda, Cybium, Thyrsites, and Gempyles. This work marked a great advance in taxonomy, and among the species from the Far East which it recorded were the sawara, ushisawara, and tomboshibi(?). From the time of Linnaeus until Cuvier these fishes had all been included haphazardly in the genus Scomber, except that Lacepede had established the genus Scomberomorus for one species of sawara. There were, however, errors in his description, and since he placed all the other kinds of sawara in the same genus with the mackerel, it is believed that the adoption of this new genus was not opportune.

In Tempo 2 (1831) Shūsaku Takei in his Gyokan mentioned the saba, sawara, maguro (maguro, meiika, kihata, mebachi, binnaga), and katsuo (suiikatsuo, sōdakatsuo, ashikagatsuo, uzuwagatsuo, yokowa).

Later Nobutoshi Okada in his Nippon Dōbutsu Sōmokuroku, Tasaku Kitahara in Vol. 6 of the Suisan Chōsa Hōkoku, Tsunenobu Fujita in Nippon Suisan Dōbutsugaku, and Jordan, Tanaka, and Snider in Vol.33 of the Journal of the College of Science have given indexes of these fishes, but they do not agree on many points, and since their classifications are based mainly on the outward form of the fish, there are many unsatisfactory points in their definitions both of genera and of species.

Scombridae (saba-ka)

The body is generally slender and flattened laterally. The dorsal surface of the head is somewhat flattened. The caudal peduncle is thick and is round in cross-section with no keels at its center. The eye ordinarily has an adipose eyelid. The corselet is not clearly defined, and the scales on the pectoral region are cycloid just like those on the rest of the body. There are many scales on the opercle, the posterior edge of which is more or less indented. The interopercular bone is covered by the operculum so that it is almost invisible. The mouth is large and the tongue is small. The teeth are small and there is a single row in each jaw. Teeth are also seen sometimes on the vomer and the palatines. The fins are small and weak, and the rays are articulated both transversely and longitudinally. The first dorsal is slightly separated from the second dorsal. The skeleton is thin and weak. There are from 31 to 33 vertebrae. The neural spine of the first vertebra is not separate from the centrum. The last vertebra is not fused to the hypural. There are numerous pyloric caeca; they all open directly into the intestine and do not branch.

The fish of this family attain lengths of about one foot, and generally occur abundantly along the coast and in bays. The genus Scomber shows that this family is close to the Carangidae in that they have adipose eyelids, separate spines in front of the anal fin, and an indentation in the posterior edge of the operculum. On the other hand, through the genus Grammatorcynus, the family is shown to be close to the Cybiidae in lacking adipose eyelids and separate spines anterior to the anal and in having flattened teeth.

There are three genera in this family, the interrelationships of which are shown below.

Lateral line is single
  Body spindle-shaped, teeth present on vomer and palatines ... Genus Scomber
  Body flattened, no teeth on vomer and palatines, gill-rakers very long and numerous ... Genus Rastrelliger
Lateral line double ..... Genus Grammatorcynus

Scomber japonicus (saba)

D. 9 - 12, 12, 5. A. 1, 12 or 13, 5. Vert. 14 + 17 Gill-rakers 13 + 23

The body is slender and an air bladder is present. The back is blue-green with many crooked black lines. The species likes warm water and is very widely distributed. It occurs in the Pacific and also, it is said, in the Atlantic. In Japan it is found from the west coast of Hokkaidō on the north to the Izu Shichitō on the south (the bones of this species have been recognized in the stomachs of fish taken

.n the Ogasawara Is.). It occurs as far south in the Pacific as Australia. The largest specimens are about 2 feet in length and weigh 400 momme [3 pounds 5 ounces], but there are said to be some in the Japan Sea which weigh 6 pounds 10 ounces. They first become sexually mature at a length of about 14½ inches (a full three years old?), and their spawning season is in May and June. They grow rapidly and appear to be over 7.2 inches long at the end of their first year. They feed on various pelagic organisms and also eat small fish.

There are two varieties of this species. One is called the hirasaba [flat mackerel] and the other is called the marusaba [round mackerel] or gomasaba [sesame mackerel?]. The differences between these two are not marked and there are specimens with all degrees of variation linking them.

The hirasaba has nine spines in the first dorsal and twelve in the anal besides the separate ones. The body is flattened and its breadth is about equal to the length of the head. The markings on the back are long, crossing the lateral line, and there are no spots visible below the lateral line. The caudal fin is yellowish. These fish occur close to shore and do not form large schools. They are said to swim at rather deep levels. They are well-flavored.

The marusaba has eleven or twelve spines in the first dorsal and thirteen in the anal besides the separate spines. The body is slender and round in cross-section. Its breadth is less than the head length. The markings of the back disappear near the lateral line, and there is a single row of spots along the middle line of the side of the body. Many gray spots are also visible on the belly. These fish are generally found in large schools off shore and are said to swim near the surface. Their flavor is not as good as that of the hirasaba.

In the Atlantic there is another species besides this one which has no air bladder. Its flavor is said to be better than that of this species.

Rastrelliger chrysozonus (agifurakiya)

D. 10, 12, 6. A. 12, 5. Vert. 13 / 18.

This is a fish about one foot in length which occurs around Amami Ōshima. It is distributed from India to the South Seas.

Cybiidae (sawara-ka)

The body is generally slender and flattened laterally. The dorsal surface of the head is somewhat rounded and convex. The caudal peduncle has a median keel which is covered with scales. The corselet is fairly distinct, but its scales are not of any special form. The part of the corselet which extends posteriorly follows the upper edge of the pectoral fin and then runs ventral to the lateral line. The scales are small and round, and are sometimes hidden under the skin. They are sometimes lacking except on the corselet. The lateral line is undulating and sometimes has small branches. The mouth is broad, the posterior edge of the maxillary is round, the teeth are large, compressed, and curved. There are villiform teeth on the vomer and palatines, however, the hakatsuo [Sarda orientalis] and the isomaguro [Gymnosarda nuda] have no vomerine teeth. The tongue is broad and large.

The fins are generally small, particularly the ventrals. The first dorsal is low and long and its spines are weak. The articulated spines are only divided longitudinally, only the ventrals being articulated transversely. The first dorsal

is almost continuous with the second, and its first spine is shorter and weaker than the following ones.

Except in the genus Sarda, the median keel of the caudal peduncle is covered with fine scales, and the cross-section of the peduncle is roughly round.

The pyloric caeca are dendriform.

The skeleton is rather coarse and the skull is long. There is no cartilage in the dorsal part of the skull, and the opening at the posterioventral end of the skull is small and opens horizontally. Scales are usually visible on the operole, the dorsal edge of which is convex.

The number of vertebrae is very indeterminate, but most species have from 40 to 50. The greatest number is found in the kamasusawara [Acanthocybium], which has 64, and the fewest in the isomaguro [Gymnosarda], which has 38. The ratio of pectoral and caudal vertebrae has not been determined. The last vertebra is fused to the hypural. The first vertebra is not fused to the cranium and its neural spine is separate.

The flesh is almost colorless, but the upper layers of tissue along the median part of the sides are slightly reddish. The flavor is generally excellent.

The fishes of this family sometimes reach very large sizes. Most of them swim near the surface in pelagic waters or close to the shore, and they are distributed between temperate and tropical waters. They form schools of varying sizes and feed voraciously on sardines, anchovies, decapterids, Trachurus japonicus, and mackerel. They sometimes leap out of the water, and they are very clever at escaping through the meshes of nets. They often damage fishing gear with their sharp teeth.

The color of the back varies between green and steel-blue, with a purplish cast in some cases, and the belly is silvery white. Although there are some fish which have longitudinal or transverse lines on the sides of the body, most of them have dark spots. Rarely individuals are found which have no markings at all. The first dorsal is ordinarily blackish.

This family approaches the broadbill swordfish in the genus Acanthocybium, which has reticulated gill filaments and no gill-rakers, while the sujikatsuo [genus Sarda], with its short thick body and scaleless keels, is closer to the Thunnidae. The flattened sharp-toothed fishes of the genus Cybium link the family to the Scombridae through the genus Grammatorcynus.

This family has four genera, the relationships of which are shown below.

Body slender, teeth in both jaws compressed and sharp, teeth on vomer
  Gill filaments connected in reticulated form ... Genus Acanthocybium
  Gill filaments not reticulated ... Genus Cybium
Body short and thick, teeth in both jaws compressed but rounded on both sides, no teeth on vomer
  No teeth on the tongue, whole body covered with scales ... Genus Sarda
  Teeth on tongue, no scales except on the corselet ... Genus Gymnosarda

There are four species of the genus Cybium in Japan (excluding Formosa), and only a single species in each of the other genera. The following shows the

relationships of the species of Cybium.

Many transverse stripes present ... Cybium multifasciatum (yokojimazawara)

Round spots present
Spots in seven or eight rows, no teeth on tongue ... Cybium niphonium (sawara)
Spots in four or five rows, teeth on tongue, body broad ... Cybium korsanum (hirasawara)
Spots large and few, in two rows, pectoral fin round ... Cybium chinense (inusawara)

Acanthocybium sara (kamasusawara)

Called sawara in Miyazaki, Kagoshima, and the Ogasawara Is., okisawara in Kanagawa, tōjinsawara in Chiba, and ōkamasu in Nagasaki.
B. 7. D. 26, 11, 9. A. 11, 9. Vert. 32 or 33 / 31 Gill-rakers 0.

The body is slender and compressed. It is covered with small scales which are long and narrow. An air bladder is present. The back is indigo, and in young specimens there are about 30 dark transverse stripes. The fins are dusky. This fish lives close to the surface in warm clear waters and does not form schools. Since it is voracious and easily takes the bait, many are caught on trolling lines. They grow to a length of 6 or 7 feet and a weight of about 83 pounds. Specimens with fairly ripe ovaries have been seen in the middle of June so the spawning season is probably around July or August. The flavor is excellent, better than that of the common Cybium niphonium, and in the Ogasawara Is. it is made into dried fish sticks. The species is distributed from Chiba, Kanagawa, Shimane, and Yamaguchi on the north to the Ogasawara Is., the Ryūkyūs, and the Philippines.

Cybium multifasciatum n.sp. (yokojimasawara)

D. 17, 15, 9. A. 14, 9. Vert. 20 / 24. Gill-rakers 1 / 2.

The body is slender and spindle-shaped, and is almost round in cross-section. The greatest depth is in the vicinity of the origin of the second dorsal. The teeth are short, triangular, and compressed. There appear to be no teeth on the vomer and palatines. The scales are small and cover the whole body. The lateral line forms a large bend below the first dorsal. There is an air bladder and there are four bends in the intestine. The back is indigo, and there are about 60 stripes on the sides. The fins are black. A specimen of this rare species was obtained through information supplied by the head of the Yamaguchi Prefecture Fisheries Experiment Station. The fish was taken in a yellowtail gillnet at Kawajiri in the middle of December, 1914. The following is the report of the head of the Station, Mr. Yozo Nakajima, concerning this species.

Some of these fish are taken from October to January, but they are most abundant in November. In Yamaguchi Prefecture they are taken in the coastal waters of Abu and Ōtsu counties, at Kawajiri, Kiwato, Oshima, and Hitsushima (the two last-named places are islands which lie off Hagimachi) in yellowtail pound nets and gillnets. They appear not to form large schools and there are never more than two or three taken at a time. They are taken in depths of about 17 or 18 fathoms, but we have heard of no case of their having been taken in water of lesser depths. They are taken only occasionally during the season mentioned above, and are never caught in very great numbers. They usually weigh about 40 or 50 pounds, and very large or very small ones are never taken. The flesh is white, oily, and firmer

than that of the common sawara. It is very tasty and is prized by gourmets.

This species probably occurs in other localities also, but we have had no reports of it yet nor has there been any mention of it in the literature. It is close to Acanthocybium sara in the shape of its teeth and the fewness of its gill-rakers.

Cybium niphonium (sawara)

Called sagoshi in Kyūshū and Wakayama.

D. 19, 15, 9. A. 15-17, 8. Vert. 22 + 28. Gill-rakers 3 + 9 or 10.

The body is slender and compressed. The teeth are lanceolate, flat, and curved inward; they are sharp on both sides. There are villiform teeth on the vomer and palatines. The tongue is large and is without teeth. The scales are small and cover the head and the whole body. The lateral line is undulating and slopes gradually from the posterior part of the first dorsal to a point below the second finlet whence it runs roughly along the median line of the body. There is no air bladder. The back is dark indigo with a greenish lustre. There are numerous small spots arranged in seven or eight or more rows. The species is widely distributed and occurs in Japan, Korea, and Kwangtung. It is particularly abundant in the waters off central Japan, diminishing in numbers to the northward and southward. It lives in turbid coastal waters, stays near the bottom in the cold season, and comes to the surface in warm weather. It attains a length of about 3 feet and a weight of about 12.4 pounds. Around May and June it comes into sounds and bays to spawn. The eggs are round and very large. The young fish are about 1.2 inches long in June, about 3.6 inches long in August, and grow to about one foot in length by the following January. The juveniles have neither spots nor stripes. The flavor is good and the ovaries are salted and dried to make a product called karasumi.

Cybium koreanum n. sp. (hirasawara)

D. 14, 18 - 21, 9. A. 18 - 21, 8. Vert. 20 + 26. Gill-rakers 3 + 10.

The body is broad with the greatest depth at a line connecting the origins of the second dorsal and the anal. The body appears to be almost scaleless. There are scales on the corselet, along the lateral line, and around the bases of the fins, but they are hidden beneath the skin. The teeth resemble those of C. niphonium, but they are fewer and larger. There are teeth on the tongue. The lateral line is undulating and follows in general the outline of the back. There is no air bladder; the intestine is long and is bent in several places. There are spots forming three or four longitudinal lines along the center of the sides of the body. The fins are black. The specimen was collected by Mr. Yōjirō Wakiya on the west coast of Korea in 1913. The fish attains a length of about 3 feet and a weight of about 15 pounds.

Cybium chinense (inusawara)

Called hasawara in Kanagawa, hoteisawara in Akita, ushisawara or kusamochi in Kanagawa, and uke in Wakayama.

D. 16, 15, 8. A. 16, 7. Vert. 18 + 22. Gill-rakers 2 + 9.

The body is compressed and the head is large and pointed. The teeth resemble those of C. niphonium. There are teeth on the tongue. The lateral line turns sharply downward at the posterior end of the first dorsal and at a point anterior to

the second dorsal it descends below the median line of the side of the body whence it follows an undulating course to the keel. The scales are small and are found all over the body. There is an air bladder. The pectorals are large and their posterior edges are rounded. Large obscure spots are arranged in two rows along the center of the sides of the body. The back is dark blue-green and most of the fins are black. The fish attains a length of 7 or 8 feet and a weight of 165 to 250 pounds. It is oily and the flavor is said to be inferior. It ranges north to Chiba Prefecture on the Pacific coast and to Akita Prefecture in the Japan Sea, while to the south it extends to the coasts of China and Formosa. It is taken only rarely. It feeds on sardines and carangids.

Sarda orientalis (sujikatsuo)

Called hagatsuo, kitsunekatsuo, shimakatsuo, and sabakatsuo in Nagasaki, tōzan in Kanagawa, and hōsan in Chiba.

D. 19, 15, 7 or 8. A. 15, 5 or 6. Vert. 25 / 20. Gill-rakers 4 / 9.

The body is short and thick, becoming somewhat longer proportionately in old fish. The teeth in both jaws are compressed, rounded on both edges, and bent inward. They are uneven in size. There is one row of teeth on the palatines, but none on the vomer. The scales are very small, except for those on the corselet, which are rather large. The lateral line is undulating, and runs from the neck at somewhat of a slant to the middle of the tail. There is no air bladder. The back is grayish indigo, and there are about six longitudinal stripes. Posterior to the second dorsal there are short markings lying in between these stripes. The dorsal fins are black. The species likes warm waters and is particularly abundant around Kyūshū, however, it is widely distributed and is seen in some numbers everywhere south of Hokkaidō on both the Pacific and Japan Sea coasts. It swims near the surface in rather turbid coastal waters and does not form large schools. The largest specimens are around 3 feet long. In the Tōkyō region fish with ripe ovaries are seen in the latter part of June, but in Kyūshū it appears that they spawn in the spring. They are said to grow very rapidly. Juveniles about 9.6 inches long have about eleven colorless transverse stripes which cut across the stripes of the back leaving eleven or twelve dark-colored transverse bands. They are voracious and easily take artificial lures. The flesh is soft and of rather poor quality. They are taken mixed in with carangids, mackerel, and skipjack. Sometimes they also come into nets which are used along the shore.

Many ichthyologists consider this species to be identical with that found off Chile in South America, but the Chilean species has vert. 22 / 22 and gill-rakers 9 / 17 and is a completely different species.

Gymnosarda nuda (iomaguro)

D. 14, 13, 7. A. 12, 6. Vert. 19 / 19. Gill-rakers 2 / 10

The body is spindle-shaped and appears to be scaleless, however, there are scales on the corselet and lateral line and around the fins, but most of them are hidden under the skin and cannot be seen. Both jaws have strong teeth which somewhat resemble those of the hagatsuo [S. orientalis]. There are no teeth on the vomer, but villiform teeth can be seen developing on the palatines and on the tongue. The lateral line roughly follows the outline of the back from its anterior end to the last spine of the first dorsal whence it runs obliquely to a point ventral to the first finlet. The back is purplish-indigo and the fins are all black,

however, the tips of the second dorsal and the anal are white. This fish occurs along the coasts of tropical and subtropical regions. It is found in the Ogasawara Is., the Izu Shichitō, and the Red Sea. It is not a numerous species. The fish are said to attain a length of several feet and a weight of several tens of kan [1 kan = 8.27 pounds]. It prefers to feed on decapterids, and the flesh is said to be soft and inferior in quality.

Family Thunnidae (shibi-ka)

The body is generally short and thick and very slender at both ends. The dorsal surface of the head is flat, and the caudal peduncle is compressed dorsoventrally with a scaleless keel on each side. The corselet is well developed and is covered by a membrane. The scales on this part of the body are much larger and thicker than the rest; there are many minute scales anterior to the base of the pectoral fin. Except in the genus Thunnus the posterior extension of the corselet follows roughly along the lateral line, and except for the same genus there are no scales aside from those on the corselet. The lateral line generally follows the dorsal outline of the body. The posterior end of the maxillary does not reach the middle of the eye, the teeth are small, conical in shape, and bend somewhat inward. It is uncertain whether or not there are teeth on any bones other than those of the jaws.

The fins are well developed, especially in the genus Thunnus. The first dorsal is high and its spines are strong. The first spine is the longest. The rays of the fins are also well developed and only those of the ventrals are articulated transversely. The caudal is stiff and forked.

The pyloric caeca are remarkably well developed and consist of a mass of fine tubules at the tips of large dendriform tubes. The whole mass is covered with a membrane and is pale yellowish in color. It is very large. The skeleton is very delicate, the dorsal surface of the skull is roughly triangular, and there is cartilage between the frontals, parietals, and occipitals. The posterior ventral foramen of the skull opens obliquely or vertically. The operculum is scaleless and its dorsal edge is indented. The first vertebra is fused to the cranium (except in the genus Auxis), and there is little variation in the number of vertebrae, which is 42 in the genus Katsuwonus and 39 in all the other genera. The haemal spines of the posterior thoracic vertebrae are long and their tips can be seen to be attached to the ribs.

There are blood vessels of a special type which run along the surface of both sides of the body from a point posterior to the pectoral fins. Groups of capillaries branch off from these blood vessels and enfold a laminar strip of tissue on each side of the spinal column. The muscle fascicles of the enfolded portion are small and soft, and the tissue is dark red in color because of the abundance of capillaries. This is what is commonly called the chiai.

The fishes of this family sometimes attain tremendous sizes, but aside from the genus Thunnus most of them weigh about 8.27 lbs. They are plentiful in the open sea and are widely distributed in the temperate and tropical zones. They form schools and feed on anchovies, sauries, sandlances, carangids, flying fish, squid, and planktonic crustaceans. The back is indigo in color and some of them have short oblique stripes on the sides of the body, black spots or stripes on the belly, or white spots and stripes on a gray background.

In the genus Thunnus this family approaches the Cybiidae. It has four genera, the relationships of which are shown below.

First dorsal continuous with second dorsal, dorsal surface of skull closed with cartilage with one pair of foramina
  Whole body covered with scales, two subcutaneous lateral vessels on each side of the body close together, teeth on both jaws and on the vomer, palatines, and mesopterygoid, vert. 18 / 21 ... Genus Thunnus (shibi-zoku)
  No scales except on corselet
    Two subcutaneous vessels on each side of the body, teeth only on the jaws, stripes on the belly, vert. 20 / 21 ... Genus Katsuwonus n.g. (katsuo-zoku)
    One subcutaneous vessel on each side, teeth in both jaws and on the vomer and palatines, oblique or longitudinal markings on the back with spots generally on the anterior pectoral region, vert. 20 / 19 ... Genus Euthynnus (yaito-zoku)
First dorsal not continuous with second dorsal, no foramen in the dorsal surface of the skull, no scales except on the corselet, one subcutaneous vessel on each side of the body, teeth in both jaws only, oblique markings on the back, vert. 20 / 19 ... Genus Auxis (mejika-zoku)

Genus Thunnus (shibi-zoku)

The first vertebra is very thin and is fused to the skull. Its neural spine is separate. There are lateral projections on several of the thoracic vertebrae. The fins are well developed, particularly in mature fish. The lateral line makes a peculiar curve above the pectoral fin. The back is dark indigo with a greenish lustre posteriorly. The belly is gray with white spots and stripes. The fins are sometimes yellowish. Most of these fishes are large-sized and form big schools. They are timid.

Five species are found in Japanese waters. Their relationships are as shown below.

The subcutaneous lateral vessels pass between the fifth and sixth vertebrae
  Pectoral fin short not reaching second dorsal, no air bladder ... Th. orientalis (kuroshibi)
  Pectoral fin very long reaching to second or third dorsal finlet, an air bladder is present ... Th. alalunga? (tomboshibi)
The subcutaneous lateral vessels pass between the seventh and eighth vertebrae
  Caudal vein does not connect directly with the Cuvierian duct, head and eye are large ... Th. mebachi n.sp. (mebachi)
  Caudal vein connects directly with the right Cuvierian duct, there are groups of capillaries below the spinal column
    Pectorals long reaching to second dorsal ... Th. macropterus (kihata)
    Pectoral does not reach second dorsal ... Th. rarus n.sp. (koshinaga)

Thunnus orientalis (kuroshibi)

Called gotoshibi in Miyazaki.

D. 12 - 15, 14, 8 or 9 A. 13 - 15, 7 or 8. Gill rakers 12 / 24.

This species is distinguished by the shortness of the pectoral and caudal fins, the marked bend in the lateral line, the absence of an air bladder, and the dark

red color of the flesh. The anterior edge of the opercle is indented, and the haemal arches of the thoracic vertebrae are very narrow and are bent markedly upward and forward. There is a dense plexus of blood vessels on the surface of the liver. On the back the color ranges from black to grayish-indigo with an indigo or greenish lustre posteriorly. The belly is grayish with white stripes and lines of white spots alternating transversely. The first dorsal is gray and the second dorsa is gray with a yellowish tip. The dorsal finlets are yellow while the anal finlets and the anal fin are silvery white. The pectorals are black and the ventrals are gray.

This species prefers comparatively cold waters. In the winter it appears in the coastal waters of Wakayama, Kōchi, and Miyazaki prefectures, but in the summer it is abundant off Iwate, Aomori, Akita, and Hokkaidō. It comes into depths of about 10 fathoms. It spawns in the summer and in the autumn juvenile fish from 6 inches to one foot long are seen. These small fish are called kakinotane in Kanagawa Prefecture, yokowa in western Honshū, and imoshibi in Miyazaki Prefecture. Young fish over one year old are called meji. The species is widely distributed and occurs in both the Japan Sea and the Pacific.

These fish grow to weights of over 579 pounds, and once in a while one is taken which weighs 827 pounds. The flesh is firm and the flavor is excellent. It is the most important of the Japanese species of the genus Thunnus.

Thunnus alalunga (tomboshibi)

Called binnaga and binchō in eastern Honshū and kantaro in Mie Prefecture.

D. 14, 14, 8. A. 14, 8. Gill-rakers 9 / 18 or 19.

This species can be easily distinguished by its extraordinarily long pectorals. The body is small and comparatively slender, but the tail is short. There is an air bladder which is very thin-walled, and which has a round simple anterior tip. The haemal spines of the thoracic vertebrae are bent markedly forward and upward. There is a dense plexus of blood vessels on the surface of the liver which resembles that of the kuroshibi [Th. orientalis]. The vertebral column is slender.

The coloration of the back ranges from black to grayish indigo with a greenish lustre posteriorly. The belly is silvery. In juvenile specimens there are irregular stripes running longitudinally on the posterior part of the belly. The edge of the first dorsal is black, the pectorals are black, the second dorsal and the ventrals are gray, and the anal is almost colorless. The dorsal finlets are gray with a yellowish tinge, and the edges of the ventral finlets are gray.

During the winter these fish are taken in the vicinity of Wakayama Prefecture. They gradually move northeastward and reach the waters off Iwate and Aomori around July. They follow the kuroshibi and precede the skipjack. They swim in schools and do not come into shallow waters. The northern and southern limits of their distribution are not clearly known, and they have never been taken in the Japan Sea and probably do not occur there. Most of those which are taken weigh from 25 to 34 pounds and individuals over 50 pounds in weight are rarely taken. The flesh is pale and soft and of inferior flavor for which reason there has been no particular fishery for this species in the past.

Thunnus mebachi n.sp. (mebachi)

Called mebachi or bachi in eastern Honshū, meppachi and darumashibi in Mie, and hirashibi or mebuto in Miyazaki.

D. 14 or 15, 13, 9. A. 13, 9: Gill-rakers 8 - 10 / 18 or 19.

The body is broad and the head and eye are large while the tail is comparatively short and slender. The air bladder is large and its anterior tip is bifurcated. The haemal spines of the thoracic vertebrae are not markedly bent forward. The foramen of the haemal arch is broad. The interopercular bone is triangular and long posteriorly. The pectorals are long, sometimes extending past the anus in juvenile specimens.

The coloration of the back ranges from black to grayish indigo, and the belly is gray or silvery. The dorsal fins are gray with a yellow tinge, and the finlets are yellowish with gray edges. The pectorals are black, sometimes with yellowish tips. The ventrals are also gray with a yellowish cast. The anal is white with a yellowish tip, and the anal finlets are similar to the dorsal ones. Sometimes one sees on juvenile specimens colorless stripes and rows of spots on a gray background in the region of the anus, but these markings cannot be seen on mature fish.

This species occurs south of about 36°N, preferring rather warm waters. It is found in the Ryūkyūs and Formosa. It is also said to occur in the Japan Sea, but this is very doubtful. It swims at deeper levels than the other thunnids and does not come in to shallow waters. The flesh is pale and soft and the flavor is inferior, particularly in young fish.

Thunnus macropterus (kihata)

Called kinhire in Miyazaki, hashibi in Kyūshū, itoshibi in Mie and Miyazaki, hatsu and hompatsu in Ehime, and hirenaga or gesunaga in Shizuoka.

D. 13, 14, 9. A. 14 or 15, 8 or 9. Gill-rakers 9 / 21.

Head and eye small, tail long. It is easily distinguished by the extremely long second dorsal and anal, which are bright yellow. The air bladder is large and its anterior edge is bifurcated. The foramen of the haemal arch is broad and is enveloped by bundles of capillaries originating from the caudal vein.

The coloration resembles that of the mebachi [Th. mebachi], but is brighter. The tips of the second dorsal and the anal are white, and the belly resembles that of Th. orientalis in having alternate white stripes and rows of white spots.

There are two varieties, one having the second dorsal and the anal developed to a great length so that they reach to the caudal, and the other lacking this development. The former is commonly called gesunaga in eastern Honshū and ōitoshibi in western Honshū.

This species prefers warm waters and is widely distributed. It occurs in the Ryūkyūs and at Formosa, and is said to appear in the South Pacific and the Indian Ocean. In Japan it is most abundant in the summer and occurs also in the Japan Sea. It ranges north to Akita Prefecture and comes in close to the shore in the summer.

In the Kyūshū region juveniles about 6 inches long are seen in the summer. These are called pinkiri in Miyazaki Prefecture. Fish about one foot long are taken

mixed with skipjack, and in eastern Honshū they are called kimeii.

The flesh is pink and firm, and the flavor is very fine.

Thunnus rarus n.sp. (koshinaga)

D. 13, 14, 9. A. 14, 8. Gill-rakers 6 / 17.

Head and eye small, snout short, tail long, body broad. There is no air bladder. The foramen of the haemal arch is broad and enveloped in bundles of capillaries originating from the arteries and veins. The pectoral fins are short.

The belly is gray with slender white spots arranged in irregular rows.

Only one specimen of this species was obtained. It had been brought from Nagasaki to the Nihombashi Fish Market. It was 2 shaku 4 sun [28.8 inches] long and weighed 1 kan 460 momme [12.1 pounds]. Its ovaries were enlarged, and there were two mackerel about 8.4 inches long in the stomach.

When a drawing of this fish was shown to Mr. Heibei Kodama, a fish dealer, he said that it is taken very rarely in large pound nets in Kyūshū during the winter, that it grows to a weight of about 25 pounds, and that it is called tongari by the fish dealers. When the drawing was shown to Mr. Kodama's assistant, he gave the same information. Probably this is a rare species with a restricted distribution, and for this reason there has been no mention of it in the past literature.

From the general appearance and the structure of the fish there is no doubt that it is a new species.

Katsuwonus n. g. (katsuo-zoku)

In the past the katsuo has been included in the genus Euthynnus [yaito-zoku], but an examination of its osteology, circulatory system, and so forth makes it appear proper to place it in a completely separate genus. Its position is between the genus Thunnus and the genus Euthynnus. There are 20 thoracic vertebrae, the same number as in Euthynnus, and 21 caudal vertebrae, the same number found in Thunnus. The genus comprises only the one species of the skipjack [katsuo].

Katsuwonus pelamys (katsuo)

D. 12 - 17, 11 - 14, 8. A. 11 - 15, 7. Vert. 20 / 21. Gill-rakers 19 / 39.

This species is easily recognized by the four or more longitudinal stripes on the sides. The gill-rakers are fine and numerous, and their inner sides have an undulating outline. The bundles of capillaries from the vein and artery ventral to the spinal column are thick and are enclosed in a kind of cage formed by the especially developed haemal spines. This part of the fish is commonly called the kurochiai [black bloody tissue]. There is no air bladder.

This species prefers warm clear waters, and its distribution is world-wide. It attains a length of over 3 feet and a weight of 49.6 pounds. It apparently spawns in pelagic waters around August.

Gennus Euthynnus (yatio-zoku)

This genus resembles Katsuwonus, but is a degenerate group. It occupies a position between the genera Katsuwonus and Auxis. The mouth is rather large and the teeth are better developed than in Katsuwonus and Auxis. The inferior branches of the suboutaneous lateral blood vessels have disappeared, and the cage formed by the haemal spines around the black bloody tissue is not as firm as in the skipjack. There are two species in the Pacific and one in the Atlantic. Only the Atlantic species has been known hitherto.

Euthynnus yaito n.sp. (yaito)

Called yaitosuma in Wakayama, yahara in Mie, watanabe, suma, segatsuo, and uramawarigatsuo in Kyushu, and hiragatsuo in Miyazaki.

D. 15 or 16, 12 or 13, 8. A. 13, 7. Vert. 20 / 19. Gill-rakers 10 / 24.

In the past this species has been considered to be identical with that of the Atlantic, but it is distinguished from Euth. thunnina by the presence of vomerine teeth, by the oblique markings on the back, and by the absence of longitudinal stripes above the lateral line.

The coloration of the back ranges from black to indigo with many irregularly-shaped spots. The fins and finlets are black or gray, and there are several black spots on the pectoral region. Individuals are seen which are over 2 feet long and weigh about 8.27 pounds. These fish appear occasionally in our southern waters, but they are not abundant. They have been found as far north as Chiba Prefecture, but the northern limit of their distribution is not clearly known. No instance of their occurrence in the Japan Sea has been reported.

This species may be identical with that which Cantor collected at Pinan [Penang?] in India and which he named Thyunnus affinis, however, he did not mention vomerine teeth and only described the outward appearance of the fish so it is impossible to decide this point.

Gennus Auxis (mejika-zoku)

This group is even more degenerate than Euthynnus, and accordingly differs widely from the other thunnids. The haemal spines of the thoracic vertebrae do not form a haemal arch, the first vertebra is not fused to the cranium, and the first and second dorsals are not continuous. There is no air bladder. It is a small fish about one foot long, the snout is short, and the coloration is roughly the same as that of E. yaito, however, there are no spots below the pectoral fin. The species occurs in both the Atlantic and the Pacific.

There are two species in Japanese waters which are distinguished by differences in the number of scales on the lateral line and in the breadth of the body, however, they are occasionally found mingled together and are both known by the same names of mejika, sodagatsuo, kogatsuo, and fukurai.

Auxis hira n.sp. (hiramejika)

Called hiragatsuo, hirasoda, soma, and suma in Wakayama, oboso, subo, and shibuwa in Shizuoka, and kobukura.

D. 10 or 11, 12, 8. A. 13, 7. Gill-rakers 9 / 30.

The dorsal surfaces are greenish-indigo, the belly is silvery white, and there are numerous irregularly-shaped spots arranged obliquely on the back. The median part of the corselet ends slightly posterior to the pectoral fin. Posterior to the end of the corselet there are only one or two rows of scales above and below the lateral line. The breadth of the body is roughly equal to the length of the head. The haemal arches of three or four of the caudal vertebrae are joined, thus retaining traces of the cage which encloses the dark bloody tissue in the skipjack and yaito.

Individuals which attain a weight of 3.3 pounds are occasionally seen, and fish taken early in August have been found to have ripened gonads.

The species is widely distributed and ranges from Hokkaidō in the north to Kyūshū. It occurs also in the Japan Sea, and is found in the Ogasawaras and Ryūkyus and probably also in the South Seas.

The dark red muscle tissue is large and the flavor is inferior. The schools come in close to the coast, and the fish are taken in the greatest numbers in the autumn.

Auxis maru n.sp. (marumejika)

Called uzuwa in Shizuoka, marugatsuo and magatsuo in Toyama, mandara, dainampo, and nodoguro in Kanagawa, mamba in Kagoshima, and also subota.

D. 9 or 10, 11 or 12, 8. A. 13, 7. Gill-rakers 10 / 35.

The median portion of the corselet becomes very narrow and ends posterior to the anal fin. The breadth of the body is less than the length of the head. The haemal arches of the caudal vertebrae do not join. These fish spawn in the summer. The range of distribution is about the same as that of Auxis hira. This is an inferior fish which has a maximum amount of dark red muscle tissue and which spoils easily.

This is probably the same species as Auxis thazard of the South Seas, however, it is not known whether thazard corresponds to A. hira or to A. maru. Bleeker's Auxis tapeinosoma may also be this species, but the figure and description of this species are very rough and unclear. Consequently I have compelled to give these fishes the new names of hira and maru.